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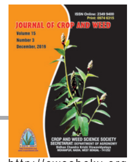

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Effect of sodium para nitrophenolate 0.3% SL on growth and yield of chilli (*Capsicum annuum* L.) in Inceptisols

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ABSTRACT

Plant growth regulator (PGR) is a non-nutritive organic substance that can change plant physiological activities at a very low concentration. Field experiments were conducted at Kalyani D Block Farm, Kalyani, Nadia under Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal during rabi and kharif seasons of 2017-18 and 2018-19. Six different treatments including sodium para-nitrophenolate (Na-p-NP) 0.3 % SL (at 4, 8 and 16 ml L^{-1}), triacontanol (TRIA) 0.1 % EW at 250 ml ha^{-1}, alpha naphthyl acetic acid (NAA) 4.5 % SL at 10 ppm and untreated control were evaluated in rabi and kharif chillies (var. Bullet Chilli) in Inceptisol. All the PGRs were applied for three times as foliar application in both the seasons at 25, 45-50 and 65-70 days after transplanting (DAT). The results revealed that the growth attributes (plant height, number of secondary branches and flowers plant^{-1}) were significantly improved with the application of Na-p-NP at 16 ml L^{-1}. It also improved the yield attributes (number of fruits plant^{-1}, fruit weight, length, width) and ultimately the fruit yield during both the seasons. There was no significant effect of PGRs on number of primary branches plant^{-1}, days to 50% flowering and maturity of chilli crop.

***Keywords*: Chilli, fruit yield, growth attributes, PGR, yield attributes.

Chilli (*Capsicum annuum* L.) is a very important spice as well as vegetable crop. As chilies are grown in all seasons in many parts of India, the fruits are accessible throughout the year. India is the largest producer, producing 1.75 million tons, and accounting for 43% of world chilli output, followed by China, Ethiopia, Thailand, Pakistan and Bangladesh (Anon., 2021a). India ranks first in terms of export and consumption of chilli. The colour and pungency levels of Indian chilli are regarded to be the world famous commercial features. Chillies from India are mostly supplied to Asian nations such as China, Sri Lanka, Malaysia, Bangladesh, Singapore, Thailand and the United Arab Emirates, among others. Andhra Pradesh comes on top in dry chilli output in the country during 2019-20, with a production record of 0.67 million tons from an area of 0.14 million hectares and productivity of 4.66 t ha^{-1}, followed by Telangana, Madhya Pradesh, Karnataka and West Bengal (Anon., 2021b).

Production of chilli is affected by a number of parameters *viz.* genetics, the environment and cultivation methods. Number of flowers and fruits decreases as a result of a hormonal and physiological abnormality in plants caused by nondurable circumstances, reducing chilli output (Vega-Alfaro *et al.,* 2021). One of the most serious issues with chillies is excessive flower and fruit dropping, which results in a low chilli production. If the drop of flowers is addressed, chilli yield may be boosted. This problem may be overcome through selecting breeding lines that preserve a high percentage of blooms, or by using physiological treatments such as spraying plant growth regulators (PGRs) to prevent flower loss (Tamilselvi and Vijayaraghavan, 2014).

The PGR is a non-nutritive organic substance that can change plant physiological activities and also becomes effective at a very low concentration (Gianfagna, 1995). They contribute to crop growth, productivity and quality by working within plant cells (Kariali and Mohapatra, 2007). They have a complete control over the quantity, direction and type of plant development, resulting in remarkable gains in plant growth and yield (Shah and Ahmad, 2006; Emongor, 2007). Although plants produce their own PGRs, various studies have confirmed that the plants may respond to exogenously applied growth hormones. Externally provided hormones can be stored by plants as reversible conjugates, which can release active hormones as per the needs of the plant throughout the growing season (Tiwari *et al.,* 2011). PGRs can improve the source-sink relationship and increase photo assimilate translocation, resulting in improved fruit set (Anolisa *et al*., 2020).

Nitrophenolates (NP) are phenolic substances that have a role in the metabolic processes of the plants. For example, they can promote development and growth, boost endogenous auxin levels, increase nutrient absorption by plant roots, and promote antioxidant and photosynthetic activities of plants (Valero *et al.,* 2014). According to the studies on the influence of PGRs on

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vegetable and fruit crops of the Solanaceae family, the use of various PGRs has been found to reduce flower and fruit drop, resulting in increased chilli yield per unit area and per unit time. Sodium para-nitrophenolate 0.3% SL (Na-p-NP 0.3%) is commonly and effectively employed in the production of the world's most significant crops. Its use in the chilli plants improves plant growth and yield (Surendar *et al.*, 2020). Chilli's distinct reactions to various PGRs have also been documented (Joshi *et al.*, 1999; Balraj *et al.*, 2002). Green pepper quality can be maintained throughout harvest and also after harvest by using gibberellic acid (dos Anjos *et al.*, 2022). Foliar application of gibberellic acid (GA), 1-Naphthaleneacetic acid (NAA), and p-Chlorophenoxyacetic acid (CPA) shows the best effect in improving fruit set (Sreenivas *et al.,* 2017; Akhter *et al.,* 2018; Mahindre *et al.,* 2018), fruit yield (Patel *et al.,* 2016; Gare *et al.,* 2017; Tapdiya *et al.,* 2018; Ahmed *et al.,* 2021), and fruit quality in chillies (Deshmukh *et al.,* 2010; Kar *et al.,* 2016; Ahmed *et al.,* 2021). Due to content of amino acids, vitamins and carbohydrates, triacontanol can boost fruit set and production in chillies (Srivastava, 2007).

With these perspectives in view, the current investigation was carried out to assess the bio-efficacy of sodium para-nitrophenolate 0.3% SL (PGR) on chilli in Inceptisols during *rabi* and *kharif* seasons.

MATERIALS AND METHODS

A field experiment was undertaken under the sub-humid subtropical climatic condition and medium land situation at Kalyani D Block Farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during *rabi* and *kharif* seasons of 2017-18 and 2018-19. The experimental site was situated in the new alluvial zone (NAZ) of West Bengal, and located at 22°58' N latitude and 88°3'E longitude with an altitude of 9.75 m above mean sea level. The soil was sandy clay loam in texture having a pH of 7.6, and mostly fertile and deep as developed from recent alluvium of the river Ganges. The variety chosen for the study was Bullet Chilli for both the seasons with duration of 144 days during *kharif* and 146 days during *rabi*. Six different treatments *viz.* sodium para- nitrophenolate (Na-p-NP) 0.3 % SL (4, 8 and 16 ml L^{-1}), triacontanol (TRIA) 0.1 % EW (250 ml ha^{-1}), alpha naphthyl acetic acid (NAA) 4.5 % SL (10 ppm) and untreated control were assigned in a randomized block design with four replications. Individual plot size was 5 m x 5 m and spacing was 60 cm x 45 cm. All the plots received the recommended doses of fertilizers at 120: 60: 60 kg N: P_2O_5: K_2O ha^{-1} in both the seasons. 50% N along with full doses of P_2O_5 and K_2O were applied as basal and incorporated into the soil at two days prior to transplanting, and the rest 50% N was top dressed at 30 days after transplanting (DAT). All the PGRs were sprayed at three times as foliar application in both the seasons, keeping the first, second and third spray at 25, 45-50 and 65-70 DAT, respectively. No pesticides were used in the study. Five plants were randomly selected and tagged from each treatment in different replicates. Observations were recorded from the selected plants only on number of primary and secondary branches $plant^{-1}$, height of the plants (cm), number of flowers $plant^{-1}$, number of fruits $plant^{-1}$, days to 50% flowering and maturity, fruit length (cm), width (cm), weight (g) and fruit yield (t ha^{-1}).

RESULTS AND DISCUSSION

Number of branches $plant^{-1}$

The treatments had a significant influence on the number of secondary branches $plant^{-1}$, whereas it was non-significant on the number of primary branches $plant^{-1}$ (Table 1). The highest number of primary and secondary branches $plant^{-1}$ was recorded under Na-p-NP at 16 ml L^{-1} in both the seasons. Maximum (4.7) and minimum (3.6) number of primary branches $plant^{-1}$ were recorded in Na-p-NP at 16 ml L^{-1} and TRIA (250 ml ha^{-1}), respectively during *rabi* season, whereas it was maximum (8.5) and minimum (5.5) in number for the secondary branches $plant^{-1}$ as recorded in Na-p-NP at 16 ml L^{-1} and untreated control, respectively. The highest number of primary branches (5.2) and secondary branches (10.5) $plant^{-1}$ in *kharif* chilli were observed in Na-p-NP at 16 ml L^{-1}, whereas these were the lowest (4.0 and 6.1 for primary and secondary branches $plant^{-1}$, respectively) in untreated control. It might be explained with the rise in the number of primary branches due to auxins activating cell elongation and cell division in the axillary buds. More number of branches was formed as a result of native cytokinin production in root cells and its subsequent transfer to the auxiliary buds. Positive effect of PGRs on branch number $plant^{-1}$ was also reported earlier (Chaudhary *et al.*, 2006; Kannan *et al.*, 2009; Kalshyam *et al.*, 2011; Vandana and Verma, 2014).

Plant height

Plant height, an essential morphological factor, was significantly influenced due to different concentrations of Na-p-NP and NAA 10 ppm. Application of Na-p-NP at 16 ml L^{-1} recorded the highest plant height (100.6 and 120.1 cm), being about 67.12% and 62.3% more than that of untreated control in *rabi* and *kharif* chilli, respectively. This might be because of the meristematic region's substantial rise in cell elongation and cell division. Na-p-NP was found to have a favourable effect on plant height (Djanaguiraman *et al.,* 2005; Kozak *et al.,* 2008; Surendar *et al.,* 2020) due to the interaction

Table 1: Effect of treatments on growth attributes of *rabi* and *kharif* chilli (pooled of two-year data)

Treatment	Primary branches plant^{-1}		Secondary branches plant^{-1}		Plant height (cm)		Flowers plant^{-1}		Days to 50% flowering		Days to maturity	
	Rabi	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*
Na-p-NP (4 ml L^{-1})	4.0	4.3	6.2	7.2	81.8	96.5	198.6	210.8	50.8	49.8	145	142.0
Na-p-NP (8 ml L^{-1})	4.3	4.8	7.1	8.1	98.5	115.7	220.8	260.3	53.5	52.6	146	144.0
Na-p-NP (16 ml L^{-1})	4.7	5.2	8.5	10.5	100.6	120.1	238.2	276.9	54.6	53.2	147	146.0
TRIA (50 ml ha^{-1})	3.6	4.1	5.7	6.4	75.2	88.7	185.3	190.6	50.5	49.3	146	144.0
NAA (10 ppm)	4.4	5.0	6.5	7.6	83.7	100.2	190.4	200.4	52.7	51.8	147	145.0
Control	3.8	4.0	5.5	6.1	60.2	74.0	170.3	183.5	49.3	49.0	144	141.0
SEm (±)	**0.08**	**0.06**	**0.33**	**0.34**	**5.73**	**6.5**	**5.21**	**5.14**	**0.02**	**0.06**	**0.03**	**0.04**
LSD (0.05)	**NS**	**NS**	**1.0**	**1.0**	**17.2**	**19.5**	**15.6**	**15.4**	**NS**	**NS**	**NS**	**NS**

NAA: Alpha naphthyl acetic acid, Na-p-NP: Sodium para- nitrophenolate, NS: Not significant, TRIA: Triacontanol

Table 2: Effect of treatments on yield attributes and fruit yield of *rabi* and *kharif* chilli (pooled of two-year data)

Treatment	Fruits plant^{-1}		Fruit length (cm)		Fruit width (cm)		Fruit weight (g)		Fruit yield (t ha^{-1})	
	Rabi	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*
Na-p-NP (4 ml L^{-1})	70.5	50.7	4.2	4.4	1.30	1.32	3.58	3.65	9.30	6.91
Na-p-NP (8 ml L^{-1})	82.0	68.5	4.5	4.7	1.51	1.52	3.92	4.00	11.82	10.84
Na-p-NP (16 ml L^{-1})	108.2	92.0	4.9	5.2	1.61	1.65	4.10	4.20	15.60	14.10
TRIA (50 ml ha^{-1})	60.8	42.7	4.0	4.3	1.36	1.40	3.43	3.50	7.56	5.80
NAA (10 ppm)	65.2	45.8	4.1	4.5	1.42	1.45	3.54	3.60	8.49	6.35
Control	54.6	37.5	3.4	3.7	1.20	1.25	3.05	3.10	6.10	4.50
SEm (±)	**2.87**	**2.70**	**0.21**	**0.24**	**0.04**	**0.03**	**0.07**	**0.07**	**0.48**	**0.43**
LSD (0.05)	**8.60**	**8.10**	**0.60**	**0.70**	**0.11**	**0.10**	**0.20**	**0.21**	**1.41**	**1.27**

NAA: Alpha naphthyl acetic acid, Na-p-NP: Sodium para- nitrophenolate, TRIA: Triacontanol

of phenolic chemicals with gibberellins, which stimulate cell elongation (Taiz and Zeiger, 2002).

Number of flowers and fruits plant^{-1}

As the number of flowers are directly related to the number of fruits of the plant, it affects the the chilli crop yield. When all PGRs were applied, the numbers of flowers and fruits produced by plant^{-1} rose dramatically when compared to the untreated control (Table 1 and 2). The highest number of flowers plant^{-1} was observed with the application of Na-p-NP at 16 ml L^{-1} (238.2 and 276.9), whereas it was the lowest in control treatment (170.3 and 183.5) during *rabi* and *kharif* seasons, respectively. Many studies reveal that application of PGRs decreases flower and fruit drops, thus increasing the chilli yield (Mahindre *et al.,* 2018; Anolisa *et al*., 2020). Similarly, the highest number of fruits plant^{-1} was observed in Na-p-NP at 16 ml L^{-1} with about 98.17 and 145.33% increase over control treatment in *rabi* and *kharif* seasons, respectively. These findings were in agreement with Chaudhary *et al.* (2006), Sarker *et al.* (2009), Das *et al.* (2015), Chouhan *et al.* (2017) and Kesumawati *et al.* (2019).

Days to 50% flowering and maturity

There was no significant effect of PGRs on the days to 50% flowering and maturity in both the seasons (Table 1). Maximum number of days (54.6 DAT) was required for 50% flowering in Na-p-NP at 16 ml L^{-1} in *rabi* chilli whereas, it was attained at 53.2 DAT in *kharif*. In contrast, the untreated control treatment took minimum time (49.3 DAT for *rabi* and 49.0 DAT for *kharif*) to attain 50% flowering. Similarly, the plots treated with Na-p-NP at 16 ml L^{-1} took maximum number of days (146 and 147 days in *rabi* and *kharif*, respectively) to mature, and the crop plants in untreated control attained maturity faster. This might be due to the enhanced vegetative growth caused by application of PGRs in early vegetative stage, and also PGRs could induce greenness for longer time due to higher photosynthetic activity. However, many contrasting results were reported on early flowering with the application of various PGRs (Kannan *et al.,* 2009; Tapdiya *et al.,* 2018).

Fruit length, width and weight

Data on fruit length of chilli indicated significant variation among different treatments (Table 2).

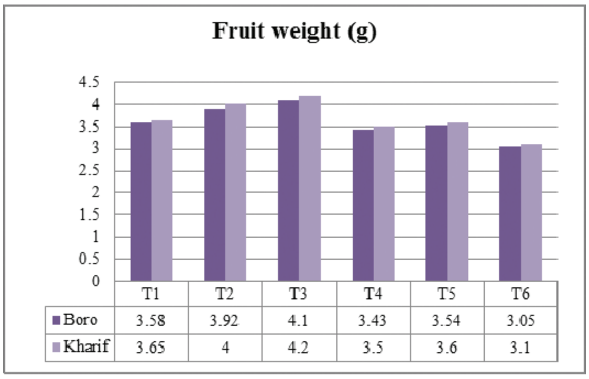

Fig. 1 : Effects of PGRs on fruit weight (g) in both seasons

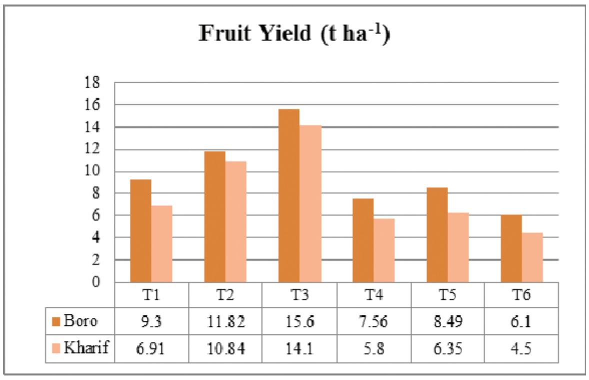

Fig. 2 : Effects of PGRs on fruit yield (t ha^{-1}) in both seasons

Maximum fruit length was observed with the application of Na-p-NP at 16 ml L^{-1} in both *rabi* (4.9 cm) and *kharif* (5.2 cm) seasons, whereas it was the lowest in untreated control. This might be affected by the availability of growth regulators within plants, causing cell expansion and elongation (Singh *et al.,* 1994). The fruit width also varied significantly with the application of PGRs (Table 2). Use of Na-p-NP at 16 ml L^{-1} recorded the highest fruit width (1.61 cm in *rabi* and 1.65 cm in *kharif*). The lowest fruit width was recorded in untreated control (1.20 cm in *rabi* and 1.25 cm in *kharif*). This might be due to the fact that the plants' increased physiological activity and vegetative growth caused a buildup of assimilates (Joshi and Singh, 2010). These results were in consonance with the findings of Sharma *et al.* (1999), Tapdiya *et al.* (2018) and Pundir *et al.* (2020).

Application of Na-p-NP at 16 ml L^{-1} recorded the highest fruit weight (4.10 g in *rabi* and 4.20 g in *kharif*) (Fig. 1), being 34.43 and 35.48% higher than the untreated control, respectively. Fruit width, length and number of seeds fruit^{-1} altogether had a positive impact on increased fruit weight with the use of Na-p-NP at 16 ml L^{-1}. These results were in conformity with the findings of Tapdiya *et al.* (2018).

Fruit yield

All the PGRs exhibited a significant influence on fruit yield. Use of Na-p-NP at 16 ml L^{-1} recorded the highest fruit yield (15.60 and 14.10 t ha^{-1}), whereas the untreated control recorded the lowest fruit yield (6.10 and 4.50 t ha^{-1}) in *rabi* and *kharif* chillies (Table 2). Compared with the untreated control, there was a significant increase in fruit yield (155.74 and 213.33%) with the application of Na-p-NP at 16 ml L^{-1}, whereas it was the lowest with the use of TRIA 250 ml ha^{-1} (23.93 and 28.89%) in *rabi* and *kharif* seasons, respectively (Fig. 2). The plants treated with PGRs produced the highest fruit yield (Balraj *et al.*, 2002; Vandana and Verma, 2014). Photosynthetic activity of plants might be increased with the use of PGRs, resulting in the increased synthesis of carbohydrates and associated products, which led to the increased fruit size and weight, and ultimately higher productivity. These results were in consonance with the earlier findings of Chaudhary *et al.* (2006), Patel *et al.* (2016), Tapdiya *et al.* (2018), Mahindre *et al.* (2018).

As revealed from the present findings, three rounds of foliar spray of Na-p-NP at 16 ml L^{-1} (25, 45-50 and 65-70 DAT) might be recommended for improving the growth, yield attributes and fruit yield of *rabi* and *kharif* chillies.

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